CLAIMS

- In a cluster of computing nodes having shared access
- 2 to one or more volumes of data storage using a parallel
- file system, a method for managing the data storage, 3
- 4 comprising:
- 5 initiating a data management (DM) application in
- 6 cluster using а data management application
- the parallel 7 programming interface (DMAPI) of file
- 8 system;
- **3** 9 receiving a request submitted to the parallel file
 - system on one of the nodes to perform an operation on a
- 10 10 11 file in one of the volumes of data storage;
- 12 obtaining a data management access right from the
- 13 14 DMAPI responsive to the request; and
 - performing the operation on the file using
- T15 access right.

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- 1 A method according to 1, wherein initiating the data 2.
 - 2 management application comprises creating a session of
 - 3 data management application on a session node
 - selected from among the nodes in the cluster, and wherein 4
 - obtaining the data management access right comprises 5
 - obtaining the right at the session node. 6
 - 1 A method according to claim 2, wherein initiating
 - 2 the data management application comprises initiating a
 - 3 data migration application, so as to free storage space
 - on at least one of the volumes of data storage, and
 - wherein receiving the request comprises generating an 5
 - event responsive to the request, and wherein obtaining 6
 - 7 the right at the session node comprises associating a DM
 - 8 token with the right at the session node for use in
 - invoking a DMAPI function to be applied to the file and 9

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- associating the token with the event, 10 and wherein
- 11 performing the operation comprises migrating data at a
- plurality of the nodes simultaneously by presenting the 12
- 13 token in connection with the DMAPI function.
- A method according to claim 2, wherein receiving the 1
- request comprises receiving an invocation of a file 2
- operation submitted to the parallel file system by a user 3
- application on a source node, and sending a notification 4
- of a DM event to the session node responsive to the 5
- request, and wherein obtaining the right at the session 6
- node comprises processing the event at the session node 7
- subject to the access right.
- Ţ A method according to claim 1, wherein obtaining the 1
- data management access right comprises acquiring a data 2
 - management lock on the file, so as to restrict other data 3
 - management and file operations on the file while the lock 4
- is held.

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- [] A method according to claim 5, wherein the operation 1 6.
 - is a data management operation, and wherein acquiring the
 - data management lock comprises holding the lock over a 3
 - sequence of multiple kernel calls in the parallel file 4
 - 5 system.
 - 7. A method according to claim 5, wherein the operation 1
 - is a file operation, and wherein acquiring the data 2
 - management lock comprises holding the lock for a single 3
 - 4 kernel call in the parallel file system.
 - A method according to claim 7, wherein the file 1
 - operation is one of a plurality of file operations to be 2
 - performed on the file, and wherein acquiring the data 3
 - 4 management lock comprises allowing the plurality of file

- 5 operations to hold respective data management locks
- 6 simultaneously without mutual conflict.
- 1 9. A method according to claim 5, wherein acquiring the
- 2 data management lock comprises acquiring an exclusive
- 3 lock.
- 1 10. A method according to claim 5, wherein acquiring the
- 2 data management lock comprises acquiring a shared lock.
- 1 11. A method according to claim 5, wherein acquiring the
- 2 data management lock comprises selecting the lock from a
- 3 table of locks provided for both file operations and data
 - management operations.
- 1 12. A method according to claim 11, wherein performing
 - the operation comprises calling a DMAPI function to
- 3 perform a data management operation, and wherein
 - acquiring the data management lock comprises acquiring,
 - in a course of executing the DMAPI function, one of the
- 6 locks provided for the file operations for the duration
- 7 of the DMAPI function, so as to enable calling the DMAPI
- 8 function without presenting a DM token.
- 1 13. A method according to claim 5, wherein acquiring the
- 2 data management lock comprises providing the data
- 3 management lock within a hierarchy of locks supported by
- 4 the parallel file system.
- 1 14. Computing apparatus, comprising:
- 2 one or more volumes of data storage, arranged to
- 3 store data; and
- 4 a plurality of computing nodes, linked to access the
- 5 volumes of data storage using a parallel file system, and
- 6 arranged so as to enable a data management (DM)
- 7 application to be initiated using a data management

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- 8 application programming interface (DMAPI) of the parallel
- 9 file system, such that when a request submitted to the
- 10 parallel file system is received on one of the nodes to
- 11 perform an operation on a file in one of the volumes of
- 12 data storage, a data management access right is obtained
- 13 from the DMAPI responsive to the request, and the
- 14 operation on the file is performed using the access
- 15 right.

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- 1 15. Apparatus according to 14, wherein the nodes are
- 2 arranged to initiate the data management application by
- 3 creating a session of the data management application on
- 4 a session node selected from among the nodes in the
- 5 cluster, and wherein the data management access right is
- 6 obtained at the session node.
- 1 16. Apparatus according to claim 15, wherein the data
- 2 management application comprises a data migration
- 3 application, which frees storage space on at least one of
- 4 the volumes of data storage, and wherein an event is
- 5 generated responsive to the request, causing the session
- 6 node to associate a DM token with the right for use in
- 7 invoking a DMAPI function to be applied to the file and
- 8 to associate the token with the event, and wherein data
- 9 are migrated at the plurality of the nodes simultaneously
- 10 by presenting the token in connection with the DMAPI
- 11 function.
 - 1 17. Apparatus according to claim 15, wherein the request
 - 2 comprises an invocation of a file operation submitted to
 - 3 the parallel file system by a user application on a
 - 4 source node, and wherein the nodes are arranged so that a
 - 5 notification of a DM event is sent to the session node
 - 6 responsive to the request, and wherein the event is

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- 7 processed at the session node subject to the access
- 8 right.
- 1 18. Apparatus according to claim 14, wherein the data
- 2 management access right is obtained by acquiring a data
- 3 management lock on the file, so as to restrict other data
- 4 management and file operations on the file while the lock
- 5 is held.
- 1 19. Apparatus according to claim 18, wherein the
- 2 operation is a data management operation, and wherein the
- 3 data management lock is held over a sequence of multiple
- 4 kernel calls in the parallel file system.
- 1 20. Apparatus according to claim 18, wherein the
- 2 operation is a file operation, and wherein the data
- 3 management lock is held for a single kernel call in the
- 4 parallel file system.
- 1 21. Apparatus according to claim 20, wherein the file
- 2 operation is one of a plurality of file operations to be
- 3 performed on the file, and wherein the plurality of file
- 4 operations are allowed to hold respective data management
- 5 locks simultaneously without mutual conflict.
- 1 22. Apparatus according to claim 18, wherein the data
- 2 management lock comprises an exclusive lock.
- 1 23. Apparatus according to claim 18, wherein the data
- 2 management lock comprises a shared lock.
- 1 24. Apparatus according to claim 18, wherein the data
- 2 management lock is selected from a table of locks
- 3 provided for both file operations and data management
- 4 operations.

- 1 25. Apparatus according to claim 24, wherein the
- 2 operation comprises a DMAPI function called to perform a
- 3 data management operation, and wherein the data
- 4 management lock comprises one of the locks provided for
- 5 the file operations, which is acquired, in a course of
- 6 executing the DMAPI function, for the duration of the
- 7 DMAPI function, so as to enable calling the DMAPI
- 8 function without presenting a DM token.
- 1 26. Apparatus according to claim 18, wherein the data
- 2 management lock is provided within a hierarchy of locks
- 3 supported by the parallel file system.
- 1 27. A computer software product providing a data
- 2 management application programming interface (DMAPI) for
- 3 use in a cluster of computing nodes having shared access
- 4 to one or more volumes of data storage using a parallel
- 5 file system, the product comprising a computer-readable
- 6 medium in which program instructions are stored, which
- 7 instructions, when read by the computing nodes, cause a
- 8 data management (DM) application to be initiated using
- 9 the DMAPI, such that when a request submitted to the
- 10 parallel file system is received on one of the nodes to
- 11 perform an operation on a file in one of the volumes of
- 12 data storage, a data management access right is obtained
- 13 from the DMAPI responsive to the request, and the
- 14 operation on the file is performed using the access
- 15 right.
- 1 28. A product according to claim 27, wherein the
- 2 instructions cause the data management application to be
- 3 initiated by creating a session of the data management
- 4 application on a session node selected from among the

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- 5 nodes in the cluster, and wherein the data management
- 6 access right is obtained at the session node.
- 1 29. A product according to claim 28, wherein the data
- 2 management application comprises a data migration
- 3 application, which frees storage space on at least one of
- 4 the volumes of data storage, and wherein the instructions
- 5 cause an event to be generated responsive to the request,
- 6 causing the session node to associate a DM token with the
- 7 right for use in invoking a DMAPI function to be applied
- 8 to the file and to associate the token with the event,
- 9 and wherein data are migrated at the plurality of the
- 10 nodes simultaneously by presenting the token in
 - 11 connection with the DMAPI function.
 - 1 30. A product according to claim 28, wherein the request
 - 2 comprises an invocation of a file operation submitted to
 - 3 the parallel file system by a user application on a
 - l source node, and wherein the instructions cause a
 - 5 notification of a DM event to be sent to the session node
 - 6 responsive to the request and cause the event to be
 - 7 processed at the session node subject to the access
 - 8 right.
 - 1 31. A product according to claim 27, wherein the data
 - 2 management access right is obtained by acquiring a data
 - 3 management lock on the file, so as to restrict other data
 - 4 management and file operations on the file while the lock
 - 5 is held.
 - 1 32. A product according to claim 31, wherein the
 - 2 operation is a data management operation, and wherein the
 - 3 data management lock is held over a sequence of multiple
 - 4 kernel calls in the parallel file system.

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- 1 33. A product according to claim 31, wherein the
- 2 operation is a file operation, and wherein the data
- 3 management lock is held for a single kernel call in the
- 4 parallel file system.
- 1 34. A product according to claim 33, wherein the file
- 2 operation is one of a plurality of file operations to be
- 3 performed on the file, and wherein the plurality of file
- 4 operations are allowed to hold respective data management
- 5 locks simultaneously without mutual conflict.
- 1 35. A product according to claim 31, wherein the data
- 2 management lock comprises an exclusive lock.
- 1 36. A product according to claim 31, wherein the data
- 2 management lock comprises a shared lock.
- 1 37. A product according to claim 31, wherein the data
- 2 management lock is selected from a table of locks
- 3 provided for both file operations and data management
- 4 operations.
- 1 38. A product according to claim 37, wherein the
- 2 operation comprises a DMAPI function called to perform a
- 3 data management operation, and wherein the data
- 4 management lock comprises one of the locks provided for
- 5 the file operations, which is acquired, in a course of
- 6 executing the DMAPI function, for the duration of the
- 7 DMAPI function, so as to enable calling the DMAPI
- 8 function without presenting a DM token.
- 1 39. Apparatus according to claim 31, wherein the data
- 2 management lock is provided within a hierarchy of locks
- 3 supported by the parallel file system.